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ORIGINAL ARTICLE

Effects of Exercise Adherence on Physical Function Among Overweight Older Adults With Knee Osteoarthritis

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Objective. **To determine whether high exercise adherence improved physical function among older adults with knee osteoarthritis (OA) who were overweight or obese.**
Methods. **Associations between exercise adherence, changes in 6-minute walking distance in meters, and self-reported disability (Western Ontario and McMaster Universities Osteoarthritis Index function subscale) after 6 and 18 months were examined among an Arthritis, Diet, and Activity Promotion Trial subsample (n = 134) using multiple linear regression models.**
Results. **Higher exercise adherence was associated with greater improvements in 6-minute walking distance after 6 and 18 months and in disability after 6 months. Pain and body mass index (BMI) contributed, to some extent, to explaining the link between exercise adherence and changes in physical performance and self-reported disability.**
Conclusion. **Higher exercise adherence is associated with improved physical function in overweight and obese older adults with knee OA. This indicates that promoting adherence is clinically relevant when prescribing exercise regimens that also focus on decreasing pain and BMI.**

KEY WORDS. Osteoarthritis; Exercise; Adherence; Physical performance; Self-reported disability.

INTRODUCTION

Knee osteoarthritis (OA) is a leading cause of decreasing physical function among older adults, and may limit a person's independence and affect health-related quality of life (1,2). In knee OA disease management, treatment options include adopting healthy lifestyles and physical exercise (3). These treatment options may also have beneficial effects on mental health (4). Compliance to treatment is important in attaining treatment goals. When a physical exercise regimen is prescribed, adherence to this regimen is crucial in preserving physical performance and function (in terms of observed walking distance and self-reported disability, respectively) and in reducing pain for patients with knee OA (5).

Generally, exercise adherence tends to decrease with intervention duration and usually results in an increase in concurrent and subsequent physical activity levels, although changes are small and generally short lived (6–9). Several studies in healthy and ill older adults showed favorable effects of exercise on muscle strength, aerobic capacity, reduction of fracture risk, and general wellbeing (7,10,11). Studies among older adults with knee OA examining effects of exercise adherence have described greater improvements in physical performance, disability, pain, quality of life, and depressive symptoms for participants who adhered to the exercise intervention (4,12,13). However, poor exercise adherence may partly have caused studies examining effects of exercise adherence in older adults who were overweight or obese to be inconclusive regarding weight maintenance and physical fitness (8,9).

Studies examining the effects of exercise intervention adherence on health outcomes in overweight and obese older adults with knee OA may offer insight into the effectiveness of exercise interventions in this growing group

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of people. By performing secondary analyses using data of the Arthritis, Diet, and Activity Promotion Trial (ADAPT), the present study examined 1) whether higher exercise adherence to an 18-month intervention program was associated with more improvements in physical performance and self-reported disability, and 2) whether changes in modifiable variables (i.e., pain, mental health, social functioning, body mass index [BMI], location of exercise) could explain the association between exercise adherence and changes in physical performance and self-reported disability.

PATIENTS AND METHODS

Design and study sample. ADAPT was a randomized controlled trial conducted among overweight and obese older adults (≥60 years) with knee OA. The study compared effectiveness of 3 different 18-month interventions—dietary weight loss, exercise, and combined dietary weight loss plus exercise—with a healthy lifestyle control group on physical function, knee pain, stiffness, weight loss, and physical performance. Data collection visits took place at baseline, 6 months, and 18 months. The study was approved of by Wake Forest University's Institutional Review Board. Sampling, data-collection procedures, information on the interventions, and main study findings have been reported in detail elsewhere (14–16).

Inclusion criteria for participation in ADAPT were as follows: 1) age ≥60 years; 2) BMI ≥28 kg/m^2; 3) knee pain on most days; 4) sedentary activity pattern for the past 6 months with <20 minutes of formal exercise once a week; 5) self-reported difficulty ascribed to knee pain in ≥1 instrumental activity of daily living (IADL); and 6) radiographic evidence of tibiofemoral OA. Potential participants were excluded if they 1) had a serious medical condition that prevented safe participation in the exercise intervention program; 2) had a mini-mental state examination score ≤23 (17); 3) could not finish the 18-month trial due to severe psychiatric morbidity or end-stage terminal illness; or 4) were unable to walk without a cane or other assistive device. Written informed consent was obtained from 316 eligible community-dwelling older adults. Subsequently they were randomly assigned to 1 of 4 study groups: 80 in the exercise group, 76 in the exercise plus dietary weight loss group, 82 in the diet-only group, and 78 in the healthy lifestyle control group. Because these last 2 groups did not contain exercise information, we included only the 2 exercise groups (n = 156) in our secondary data analyses.

Intervention. The exercise intervention was intended to expand aerobic and resistance-training capacities for participants in the exercise-only and exercise plus diet intervention groups. The 3 day/week exercise program consisted of 2 15-minute aerobics phases, during which participants walked within 50–85% of their heart rate reserve, that were separated by a resistance-training phase (20 minutes), which consisted of 2 sets of 12 repetitions of the following exercises: leg extension, leg curl, heel raise, and step up. Ankle cuff weights and weighted vests were used to provide resistance. Five minutes of warming up and cooling down started and ended each session. The initiation phase (months 1–4) was held at the facility. After the transition phase (months 5 and 6), participants could either choose to exercise at home, exercise in a facility-based program, or to combine both options in the maintenance phase (months 7–18). Those who had opted for the home-based program or combined program were expected to exercise as much as the facility-based participants—60 minutes, 3 days/week—and had to keep daily exercise logs, in which they were asked to carefully report on exercise frequency, duration, and achieved heart rate. To provide supervision, study staff contacted these participants by telephone biweekly during the first 2 months of home-based exercise, triweekly during the following 2 months, and monthly thereafter. If participants did not show up at intervention sessions, they were contacted by telephone.

Measurements. *Evaluation of exercise adherence.* Percentage exercise regimen adherence was measured by dividing the number of exercise sessions the participant actually attended or exercised at home (exercise log) by the number of prescribed sessions, multiplied by 100 (15). We calculated percentage exercise adherence for the first 6 months (called initiation phase) and overall percentage exercise adherence (months 1–18). Scores range from 0 to 100 on both variables, with higher scores indicating greater exercise adherence.

Physical performance. The 6-minute walk test was used at each study assessment to study physical performance (18). Change in walking distance in meters was defined as followup minus baseline walking distance, with higher change scores indicating more improvement in walking distance. Two-week test–retest reliability of walking distance has been reported to be 0.87 for patients with knee OA (19). Participants were encouraged to complete the test with their best effort without wearing a watch (20).

Osteoarthritis-related disability. At each study assessment, we used the 17-item function subscale of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (21) to assess self-reported OA-related disability in IADL. Scores range from 0 to 68, with higher scores indicating more disability in IADL. Change in disability was defined as followup minus baseline score, with lower change scores indicating more improvement. The WOMAC has been extensively validated, used in comparative studies to other health status measures, and applied in clinical research and clinical practice settings (22). Cronbach's alpha of the WOMAC function subscale at baseline was 0.94.

Confounding variables. Nonmodifiable demographic information (age, sex, and ethnicity) was collected by self report. Analyses were adjusted for whether or not participants in the exercise groups also received a diet intervention. Furthermore, because change in walking distance and disability are outcome measures, we adjusted analyses for baseline levels of these outcome measures.

Potentially explanatory variables. We used the pain subscale of the WOMAC (21) and changes in this subscale over time to assess self-reported OA-related pain at baseline and followup visits. Scores range from 0 to 20, with higher scores indicating more pain. We used the social functioning and mental health subscales of the Short Form-36 health survey and changes in these subscales to assess these domains of health-related quality of life at baseline and followup visits (23). This widely used generic health status instrument has been reported to be a psychometrically sound tool to assess health status of participants with OA (24). Scores range from 0 to 100, with higher scores indicating greater quality of life. BMI and changes in BMI over time were calculated using weight in kilograms divided by the square of height in meters. Also, participant's choice of location of exercise was considered to be an explanatory variable (9). All change scores in potentially explanatory variables were defined as followup minus baseline score. Hence, lower change scores in pain and BMI indicate more improvement in pain and BMI, whereas higher change scores in mental health and social functioning indicate more improvement in mental health and social functioning.

Statistical analyses. Because overall exercise adherence did not differ between the 2 exercise intervention groups (54.5% exercise only versus 52.9% exercise plus diet; P = 0.74), we merged exercise groups together for further analyses on the impact of exercise adherence on change in walking distance and disability. To do so, we had to verify that intervention assignment (exercise only or exercise plus diet) did not modify the association between exercise adherence and physical outcomes. Consequently, we compared means of walking distance and disability at baseline using t-tests and examined the significance of interaction terms between intervention assignment × exercise adherence on changes in walking distance and disability in multiple linear regression analyses. Baseline mean ± SD of walking distance (exercise only 423.9 ± 75.3 meters versus exercise plus diet 411.0 ± 88.2 meters; P = 0.389) and disability (exercise only 23.8 ± 10.3 versus exercise plus diet 23.6 ± 11.9; P = 0.923) did not differ between intervention groups. We found no significant interaction effects, showing that the link between exercise adherence and change in physical outcomes was not different for participants who were assigned to exercise only versus exercise plus diet interventions.

To examine associations between percentage exercise adherence and change in walking distance and disability, we conducted multiple linear regression analyses, adjusted for confounding variables. These analyses were conducted for exercise adherence during months 1–6 and changes in outcomes after 6 months, as well as for overall exercise adherence (months 1–18) and changes in outcomes after 18 months. Outliers in the distribution of the variable change in walking distance after 6 months—scores below and over the 2.5 percentiles—were transformed into the value of the lower and upper 2.5 percentiles, −84.1 and 169.9 meters, respectively, to ensure that all outcome variables were distributed normally. Hereafter, tertile scores of percentage exercise adherence were created by dividing participants into 3 equally large categories: 1) low adherence, 2) intermediate adherence, and 3) high adherence to the exercise regimen for both the initiation phase (≤62%, n = 46; 63–82%, n = 43; and ≥83%, n = 45, respectively) and overall study duration (≤40%, n = 45; 41–70%, n = 44; and ≥71%, n = 45, respectively). Univariate analyses of covariance (ANCOVA) were used to examine differences in estimated means in changes in walking distance and disability after 6 and 18 months between adherence categories, with low adherence as the reference category, adjusted for confounding variables. Because a potentially mediating or explanatory variable in an association has to correlate with both the independent and the dependent variable, correlations between potentially explanatory variables and percentage exercise adherence, and correlations between potentially explanatory variables and change in walking distance and change in disability were examined. Finally, multiple linear regression models were computed in which each potentially explanatory variable was entered as covariate, after adjusting for confounding variables, to explore their contribution in explaining the associations between exercise adherence and change in physical performance and disability. The a priori level of significance used in all analyses was 0.05.

RESULTS

Of the 156 participants, 69 (86.3%) of the exercise-only group and 65 (85.5%) of the exercise plus diet group were still exercising after the 18 months of the study. Analyses of variance and chi-square tests indicated that respondents lost to followup (n = 22) did not differ from participants (n = 134) on any of the baseline variables (all $P > 0.05$) or on intervention assignment (P = 0.90). Participants' mean ± SD age was 68.5 ± 6.3 years (n = 134), 72.2% were women, 76.1% were white, 57.6% were married, and 68.7% were educated >12 years.

Mean ± SD exercise adherence was 65.6 ± 27.1% in the initiation phase and 53.7 ± 29.4% overall (n = 134). Mean walking distance at baseline was 417.4 ± 81.9 meters, and ranged from 141 to 650 meters. After 6 and 18 months, significant mean improvements in walking distance were observed compared with baseline: 50.1 ± 54.9 meters and 46.4 ± 65.4 meters, respectively (both $P < 0.01$). Mean ± SD disability score at baseline was 23.7 ± 11.1, and ranged from 2 to 68. After 6 and 18 months, significant mean improvements in disability were observed compared with baseline: –3.6 ± 9.2 and –3.5 ± 9.9, respectively (both $P <$ 0.01). After the initiation phase, 37 (27.6%) participants chose to continue their intervention exercises (at least partly) at home and 97 (72.4%) participants continued doing their exercises solely at the facility.

Table 1 shows the standardized linear regression coefficients (β) of both initiation phase and overall exercise adherence on 6- and 18-month changes in walking distance and disability, adjusted for age, sex, ethnicity, intervention assignment, and baseline levels of outcome variables. Exercise adherence in the initiation phase and during overall study followup was associated with, respectively, 6-month improvement in walking distance (P = 0.002) and 18-month improvement in walking distance

Table 1. Adjusted standardized linear regression coefficients, adjusted estimated means, 95% confidence intervals, and *P* values of exercise adherence on changes in walking distance and disability

	Change in walking distance after 6 months, meters			Change in disability score after 6 months			Change in walking distance after 18 months, meters			Change in disability score after 18 months		
	β or estM*	**95% CI**	***P***	**β or estM***	**95% CI**	***P***	**β or estM***	**95% CI**	***P***	**β or estM***	**95% CI**	***P***
Exercise adherence, initiation phase												
Exercise adherence, % (continuous)	0.28	0.25, 1.07	0.002	−0.23	−0.14, −0.03	0.001						
Exercise adherence, % (tertiles)												
Low (≤62%; n = 46)	35.2	17.4, 53.0	Ref†	−0.3	−2.6, 2.0	Ref†						
Intermediate (63–82%; n = 43)	50.4	33.0, 67.9	0.233	−6.4	−8.7, −4.1	< 0.001						
High (≥83%; n = 45)	63.5	47.4, 79.7	0.024	−3.6	−5.8, −1.4	0.049						
Exercise adherence, overall												
Exercise adherence, % (continuous)							0.39	0.48, 1.30	< 0.001	−0.18	−0.12, 0.00	0.052
Exercise adherence, % (tertiles)												
Low (≤40%; n = 45)							21.2	−2.3, 44.8	Ref†	−1.3	−4.7, 2.1	Ref†
Intermediate (41–70%; n = 44)							45.0	24.9, 65.1	0.135	−4.9	−7.9, −1.8	0.121
High (≥71%; n = 45)							68.3	50.0, 86.6	0.002	−5.9	−8.9, −2.9	0.047

* Standardized linear regression coefficients (β) are adjusted for age, sex, ethnicity, intervention assignment, and baseline levels of physical outcome measures and are given for the continuous variables. Adjusted estimated means (estM) are derived from analyses of covariance and are given for the tertiles.
† Ref = the reference group.

($P < 0.001$). Exercise adherence in the initiation phase was associated with 6-month improvement in disability ($P = 0.001$).

Results from ANCOVA analyses show that participants in the intermediate and highest adherence tertiles improved 15.2 and 28.3 meters more, respectively, in walking distance after 6 months, compared with those in the lowest adherence tertile ($P = 0.233$ and $P = 0.024$, respectively; Table 1). Participants in the intermediate and highest tertiles improved 23.8 and 47.1 meters more, respectively, in walking distance after 18 months, compared with those in the lowest adherence tertile ($P = 0.135$ and $P = 0.002$, respectively; Table 1). For walking distance, the tertile analyses confirmed a dose-response association, because the highest adherence tertile had the greatest improvement after 6 and 18 months.

Participants in the intermediate and highest adherence tertiles improved 6.1 and 3.3 units more, respectively, in disability after 6 months, compared with those in the lowest adherence tertile ($P < 0.001$ and $P = 0.049$, respectively; Table 1). Participants in the intermediate and highest adherence tertiles improved 3.6 and 4.6 units more, respectively, in disability after 18 months, compared with those in the lowest adherence tertile ($P = 0.121$ and $P = 0.047$, respectively; Table 1).

As shown in the Pearson correlation Table 2, most of the potentially explanatory variables—except for social functioning and location of exercise—were either significantly correlated with both exercise adherence and change in walking distance or were significantly correlated with both exercise adherence and change in disability. Prominent results of correlation analyses were that improvements in pain and improvements in mental health were correlated significantly with improvements in disability. Improvements in pain and decreased BMI were correlated significantly with increased walking distance (Table 2).

Table 3 shows multiple linear regression models examining the associations between exercise adherence and change in walking distance after 6 months and after the entire duration of the study. In these analyses, we explored the influence of each potentially explanatory variable separately by entering it into a model, which is already adjusted for potentially confounding variables. After adjustment for confounding variables, high 6-month exercise adherence was significantly associated with greater 6-month improvements in walking distance ($\beta = 0.28$, $P = 0.002$). When we entered baseline BMI and 6-month change in BMI in the multiple linear regression model with 6-month exercise adherence as the independent variable and 6-month change in walking distance as the dependent variable—after initial adjustment for confounding variables—the standardized regression coefficient dropped substantially to 0.24 ($P = 0.013$; Table 3). To a lesser extent, this also happened when baseline and 6-month change in pain ($\beta = 0.26$, $P = 0.004$), baseline and 6-month change in mental health ($\beta = 0.26$, $P = 0.007$), and baseline and 6-month change in social functioning ($\beta = 0.26$, $P = 0.007$) were entered (Table 3).

After adjusting for confounding variables, high overall exercise adherence was significantly associated with greater 18-month improvements in walking distance ($\beta = 0.39$, $P < 0.001$). When we entered baseline BMI and 18-month change in BMI in the multiple linear regression model, with overall exercise adherence as the independent variable and 18-month change in walking distance as the dependent variable—after initial adjustment for confounding variables—the standardized regression coefficient dropped substantially to 0.28 ($P = 0.004$; Table 3). The other potentially explanatory variables did not have that kind of effect on the original association (Table 3).

Table 4 shows multiple linear regression models examining the associations between exercise adherence and change in disability after 6 months and after the entire duration of the study. As before, we explored the influence of each potentially explanatory variable separately by entering it into a model, which is already adjusted for potentially confounding variables. After adjusting for confounding variables, high 6-month exercise adherence was significantly associated with greater 6-month improvements in disability ($\beta = -0.26$, $P = 0.001$). When we entered baseline pain and 6-month change in pain in the multiple linear regression model, with 6-month exercise adherence as the independent variable and 6-month change in disability as the dependent variable—after initial adjustment for confounding variables—the standardized regression coefficient dropped to -0.15 ($P = 0.019$; Table 4). This also happened with baseline and 6-month change in social functioning ($\beta = -0.16$, $P = 0.035$), baseline and 6-month change in mental health ($\beta = -0.17$, $P = 0.036$), and baseline and 6-month change in BMI ($\beta = -0.20$, $P = 0.022$). The other potentially explanatory variables did not have that kind of effect on the original association (Table 4).

After adjusting for confounding variables, high overall exercise adherence was not significantly associated with greater 18-month improvement in disability ($\beta = -0.18$, $P = 0.052$). When we entered baseline pain and 18-month change in pain in the multiple linear regression model, with overall exercise adherence as the independent variable and 18-month change in disability as the dependent variable—after initial adjustment for confounding variables—the standardized regression coefficient dropped to -0.06 ($P = 0.355$; Table 4). This also happened with baseline and 18-month change in BMI ($\beta = -0.11$, $P = 0.276$). The other potentially explanatory variables did not have that kind of effect on the original association (Table 4).

DISCUSSION

Our study provides evidence that exercise adherence is associated with improvements in observed physical performance and self-reported disability. We found that, after adjustment for confounding variables, higher exercise adherence goes together with greater improvements in walking distance after 6 and 18 months, and with greater improvements in disability after 6 months. Pain, mental health, and BMI correlated both with exercise adherence and with changes in walking distance and disability. Because of these associations, these variables were able to contribute, to some extent, in explaining the link between exercise adherence and changes in physical performance and self-reported disability.

Table 2. Pearson correlations between percentage exercise adherence, changes in walking distance, changes in disability, and potentially explanatory variables among exercise intervention participants (n = 134)*

	Exercise adherence months 1–6	Exercise adherence months 1–18	Change in walking distance after 6 months, meters	Change in walking distance after 18 months, meters	Change in disability score after 6 months	Change in disability score after 18 months
Baseline pain	−0.01	−0.09	0.07	−0.04	−0.31†	−0.21‡
6-month change in pain	−0.20‡		−0.21‡		0.64†	
18-month change in pain		−0.17		−0.27†		0.68†
Baseline mental health	0.07	0.05	−0.05	−0.11	−0.04	0.06
6-month change in mental health	0.26†		0.15		−0.23†	
18-month change in mental health		0.14		0.19		−0.31†
Baseline social functioning	0.12	0.15	−0.06	−0.01	−0.08	0.03
6-month change in social functioning	0.04		0.19		−0.29†	
18-month change in social functioning		0.05		0.17		−0.21‡
Baseline BMI	−0.26†	−0.29†	0.01	−0.06	0.03	−0.06
6-month change in BMI	−0.20‡		−0.24‡		0.14	
18-month change in BMI		−0.27†		−0.21‡		0.08
Location of exercise, at home (0) versus solely at facility (1)	−0.12	−0.26†	−0.03	−0.15	0.23†	0.16

* All change scores are defined as followup scores minus baseline scores. Negative change scores in pain, BMI, and disability indicate improvement and positive change scores in mental health, social functioning, and walking distance indicate improvement. BMI = body mass index.
† $P < 0.01$.
‡ $P < 0.05$.

Table 3. Multiple linear regression models of percentage exercise adherence over 6 and 18 months on changes in walking distance in meters, after adjustment for potentially confounding and explanatory variables (n = 134)*

		6-month change in walking distance			18-month change in walking distance		
		β	95% CI	P	β	(95% CI)	P
Model 1	Potentially confounding variables†	0.28	0.25, 1.07	0.002	0.39	0.48, 1.30	< 0.001
Model 2	Potentially confounding variables plus baseline and change in pain	0.26	0.25, 1.01	0.004	0.37	0.44, 1.28	< 0.001
Model 3	Potentially confounding variables plus baseline and change in mental health	0.26	0.17, 1.04	0.007	0.38	0.47, 1.31	< 0.001
Model 4	Potentially confounding variables plus baseline and change in social functioning	0.26	0.17, 1.01	0.007	0.36	0.40, 1.26	< 0.001
Model 5	Potentially confounding variables plus baseline and change in BMI	0.24	0.12, 0.98	0.013	0.28	0.21, 1.11	0.004
Model 6	Potentially confounding variables plus location of exercise	0.28	0.25, 1.08	0.002	0.38	0.47, 1.30	< 0.001

* 95% CI = 95% confidence interval; BMI = body mass index.
† Potentially confounding variables include age, sex, ethnicity, intervention assignment, and baseline levels of walking distance.

In our 18-month study, percentage exercise adherence in the initiation phase (65.6%) was higher than overall exercise adherence (53.7%). Considering the fact that our sample consisted of overweight and obese older adults with knee OA, we conclude that both percentages are in line with current literature regarding adherence rates (25).

Exercise adherence was a significant predictor of greater improvements in walking distance, even when potentially explanatory variables were taken into account. Moreover, ANCOVA analyses revealed that the tertiles with the participants who had the best adherence improved significantly more in walking distance between baseline and 6- and 18-month followup compared with the tertile of participants who had the poorest adherence. So, in line with a dose-response association, our study showed that the more participants adhere to the exercise regimen, the more they improve on walking distance.

We also found a significant association in the short-term period between high exercise adherence and improvement in disability. Possible explanations for the association between exercise adherence and disability not being sustained after 6 months could be that the first 6 months of the intervention were very intensive, with exercise sessions at the facility for at least 4 months. Thereafter, exercise adherence decreased and participants' improvement in disability could have stagnated. Secondly, knee OA is an aggravating condition; hence it is possible that the participants' condition declined and self-reported disability worsened. Both short- and long-term ANCOVA analyses revealed that the tertile with participants who had highest adherence rates improved significantly more in disability compared with the tertile of participants who had the poorest adherence.

A potentially mediating or explanatory variable in an association has to correlate with both the independent and the dependent variables. We found significant correlations

Table 4. Multiple linear regression models of percentage exercise adherence over 6 and 18 months on changes in disability, after adjustment for potentially confounding and explanatory variables (n = 134)*

		6-month change in disability			18-month change in disability		
		β	95% CI	P	β	95% CI	P
Model 1	Potentially confounding variables†	−0.26	−0.14, −0.03	0.001	−0.18	−0.12, 0.00	0.052
Model 2	Potentially confounding variables plus baseline and change in pain	−0.15	−0.09, −0.01	0.019	−0.06	−0.07, 0.02	0.355
Model 3	Potentially confounding variables plus baseline and change in mental health	−0.17	−0.11, 0.00	0.036	−0.14	−0.11, 0.01	0.091
Model 4	Potentially confounding variables plus baseline and change in social functioning	−0.16	−0.10, 0.00	0.035	−0.14	−0.11, 0.02	0.140
Model 5	Potentially confounding variables plus baseline and change in BMI	−0.20	−0.14, −0.01	0.022	−0.11	−0.11, 0.03	0.276
Model 6	Potentially confounding variables plus location of exercise	−0.24	−0.13, −0.03	0.002	−0.16	−0.12, 0.01	0.088

* 95% CI = 95% confidence interval; BMI = body mass index.
† Potentially confounding variables include age, sex, ethnicity, intervention assignment, and baseline levels of disability.

between independent and dependent variables for most, but not all, potentially explanatory variables. Overall, the choice of our potentially explanatory variables seemed justified.

From our multiple linear regression analyses, it seemed that especially BMI during the intervention period was a contributing variable in explaining the association between high exercise adherence and improvement in physical performance. Pain during the intervention period was the most contributing variable in explaining the association between exercise adherence and improvement in self-reported disability.

Our results showing a positive link between exercise adherence and improvements in physical performance and self-reported disability are in line with those of Ettinger and colleagues (12). They also found significant associations between high exercise adherence and improvements in physical performance and disability in a sample that consisted of obese older adults with knee OA. As in other studies, we found significant correlations between high exercise adherence and improvements in pain (5,12). Rejeski and colleagues suggested that changes in knee pain may mediate effects of exercise interventions on disability (26). From our analyses, it also seemed that decrease in pain during the intervention period was a contributing variable in explaining the association between high exercise adherence and improvement in disability. Although it is plausible that exercise does improve pain levels, a reciprocal association might also be present: participants in great pain being less likely to exercise and thus not adhering to prescribed exercise regimens. Participants who do not adhere to exercise regimens are not exercising enough, perhaps due to their physical complaints, and will therefore not experience beneficial effects of exercise on pain. Either way, not exercising enough could trap persons into a downward spiral, where inactivity stimulates pain levels and pain results in more inactivity, which eventually could end in loss of independence.

Empowering patients with knee OA through self-management courses could break the above mentioned downward spiral. If patients learn to attribute their symptoms in a cognitive way, beliefs of control over the disease may increase, levels of fear may decrease, and through the decrease of perceived barriers, patients may no longer be hesitant about physical activity. Subsequent perceived benefits of exercise on pain and disability may eventually result in better disease control. Rejeski et al (26) already concluded that beliefs of control mediated the effects that exercise programs had on disability and health perceptions in a study among patients with knee OA.

A decrease in BMI was an important mediating variable in the associations of exercise adherence with physical performance and self-reported disability. A decrease in BMI can be associated closely with decreased pain and improved stamina, and thus have an effect on physical performance and self-reported disability. However, a decrease in BMI can also be associated with improvements in physical impediments, such as decreased skinfold thickness and increased dynamic balance, and result in improvements in physical performance and self-reported disability.

In our study, adherence was measured in terms of attendance of exercise sessions, and not actual level of participation. To some extent, this obscures the actual effect of the intervention on physical function. However, attendance of intervention sessions is crucial for participants to acquire knowledge and skills regarding the core elements of an intervention. Therefore, we believe that measures of intervention attendance reflect a certain precursory value of the extent to which a participant is really physically active. It would serve comparison of results if more exercise studies would use attendance measures in their design.

We believe the strength of our study is that we explored the association between exercise adherence and concurrent changes in physical function, over a short-term and a long-term period, and tried to explain this association with modifiable, potentially explanatory variables. Our findings show that higher exercise adherence goes together with greater physical improvements in a dose-response fashion; higher exercise adherence also goes with improvements in self-reported disability. Consequently, promoting exercise adherence appears to be clinically relevant when prescribing exercise regimens, which also focus on improvements in knee pain and BMI, to overweight older adults with knee OA.

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